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FRACTURES OF THE SHAFT OF THE FEMUR IN THE ADULT.

The study of fractures of the femur is always important, but never more so than in war-time. Gunshot fractures of the shaft are a major problem in the services: they are a threat to the patient's life, and even in the most favourable cases they cause an inconveniently long stay in hospital and often lead to the discharge of the patient from the fighting forces.

In the following article the special features of subtrochanteric and supracondylar fractures of the femur are discussed only as they affect the form of treatment. Reduction and immobilization are the main subjects considered. It is not desired to under-estimate the critical importance of first aid, resuscitation from shock, and, in the case of compound fractures, of wound excision and prevention of infection; but these subjects have been previously discussed. A section is included on the transport of patients with fractured femur from the casualty clearing station to the base hospital, since many surgeons, following the Syrian and North African campaigns, reported their views on this difficult problem. In another section the experience in the treatment of fractured femur at two Australian general hospitals abroad is summarized.

Transport to Base Hospital.

It has been stated that the Thomas splint was the greatest single life-saving measure adopted during the Great War. This comprehensive claim would probably not withstand close investigation, but it is an indication of the value placed on the use of the splint for transport of patients with fractured femur. The present war, however, has given proof that, when the patient requires transport for a couple of days over rough roads, there is, at present, no method of immobilization completely free from objection. The most common way of preparing a patient for such transport is to apply a Thomas splint and use various kinds of fixed extension. A greater degree of extension is necessary than is required for treatment of the same patient in hospital. Further, unless the splint is tied very tightly to the uprights of the suspension apparatus on the stretcher, a distressing lateral sway of the whole fractured limb develops. Therefore each bar of the splint is tied separately to the corresponding horizontal and vertical limbs of the suspension apparatus. The splint is also bound down to the stretcher in order to prevent bouncing movements.

There are five chief methods of applying the fixed extension.

1. A rolled bandage or similar material may be fastened to the foot by means of a bottle knot or modified clove hitch, and the two free ends tied over the notch at the end of the splint. This is very satisfactory for short periods, but it should not be used when the patient is faced with a journey of a couple of days' duration, for, after long use, it causes painful pressure sores on the dorsum of the foot and over the tendon of Achilles.

2. A metal skewer passed through the boot gives a more satisfactory means of applying traction. The pressure is still transmitted indirectly to the same regions as before, however, and, in time, pain is caused.

3. The Millbank clip or similar apparatus is more convenient than the metal skewer.

4. Strapping extension may be applied, but it is liable to slip and become ineffective.

5. A Kirschner wire may be inserted through the crest of the tibia and traction exerted through it. The Thomas splint is bent through an angle of about 30° at the site corresponding to the knee joint. The cord from the stirrup is prevented from fouling the foot or toes by being taken round the sides of a metal foot-piece attached to the splint.

All types of fixed extension have the disadvantage that they do not provide for the relaxation of any muscle spasm that may have been present at the time the splint was applied. The ambulance driver should inspect the extension cords from time to time, especially if the patient complains of pain. Pain may be caused either when the cords are too tight or when they are too loose. It also results when the ring is so large that it slips beyond the ischial tuberosity, with the result that the medial part causes pressure on the perineum. It is often difficult to obtain a Thomas splint that fits the patient accurately.

A well-fitting plaster spica may be used as an alternative to the Thomas splint. This was done successfully in the evacuation of patients by sea from Tobruk, but orthopædic surgeons, an orthopædic table and plaster equipment were available at this place. Casualty clearing stations do not normally have a fracture table, even if they can satisfy the other requirements. The widespread use of plaster immobilization in transporting these patients is therefore, unfortunately, impracticable. Casts prepared in the absence of proper facilities are unsatisfactory.

Immobilization of Fractures of the Shaft of the Femur.

There are six main methods of immobilizing these fractures, but each method has several variations:[a] (*a*) skeletal traction; (*b*) use of plaster cast; (*c*) skin traction, usually with fixed extension on a Thomas splint; (*d*) skin traction by Russell's method; (*e*) automatic ambulatory method; and (*f*) open reduction and plating.

Skeletal Traction.

Skeletal traction is most frequently applied by means of a Kirschner wire or Steinmann pin passing through the crest of the tibia just below the tuberosity. This site is accessible, and remote from both the knee joint and the site of fracture. The Steinmann pin is simple to insert and unlikely to break, but it makes a hole one-eighth of an inch in diameter. The Kirschner wire makes a smaller hole and is therefore less liable to cause infection. Sometimes the pin or wire is put through the supracondylar part of the femur. This gives a more direct control of the lower fragment and avoids the risk of an unstable knee joint. It also leaves the knee joint free for exercise, but even slight infection may cause adhesions which limit

joint function. In any case, supracondylar traction is contraindicated in compound fractures of the femur and in any fracture of the lower third of the shaft.

The two main splints used in this method are the Thomas and the Braun. The latter suffers from the disadvantage that movement at the fracture site is likely to be caused by any change in position of the patient's body, such as the raising of the pelvis for nursing purposes. The Thomas, on the other hand, can be so suspended and counter-balanced that it moves with the patient, and in so doing does not alter the direction of the traction. The Braun splint has a further disadvantage when used in the treatment of fractures of the upper third of the shaft of the femur. In these cases there is a flexion deformity of the upper fragment and the Braun splint can permit only a certain fixed amount of flexion of the lower fragment. This may not be adequate in any given case to bring the two fragments into alignment.

Technique of Using the Thomas Splint with Balanced Skeletal Traction.

The splint is provided with a Pearson's flexed knee attachment and the traction is exerted through the slightly flexed knee joint in a line as close to the line of the tibia as possible. In this way the pull is transmitted through the joint with the least amount of strain on the ligaments. A common fault is to flex the knee too much, for in this case the knee joint can be protected only by pulling along the line of the tibia and so using the force at a considerable mechanical disadvantage.

In setting up the apparatus, the Kirschner wire is inserted into the tibia while the leg is held in temporary extension; the splint is adjusted and suspended from the overhead beam; a stirrup is attached to the transfixion pin, and a cord bearing a weight of about twenty pounds is tied to the stirrup. The foot of the bed has to be raised twelve inches to secure counter-traction, but the suspension of the Thomas splint also contributes to the counter-traction, since the suspending weights press the splint upward and cranially onto the skin of the ischial tuberosity.

The position of the fragments is checked by radiographic examination every twenty-four hours until accurate reduction has been maintained for forty-eight hours; then examination is made once a week for a month, and subsequently at longer intervals. Reduction gradually occurs, and when it is complete the traction force must be decreased, since over-traction is an important cause of non-union.

From the first day the patient practises quadriceps drill for five minutes in every hour. Movements at the knee should be begun at the end of the first week, and the knee should be put through as full a range of movement as possible three times a day. In this way muscle wasting is reduced and a fair range of movement at the knee is preserved.

Firm union is normally to be expected in three or four months. When it occurs the wire is removed and the leg is kept in the splint without traction for a week. If no pain is experienced and if the skiagram shows that the position has been maintained, the splint is removed. The patient remains in bed for a further week and then begins walking with the aid of a calliper.

Skeletal traction is undoubtedly the most certain method of reducing and maintaining fractures which require strong traction, such as oblique fractures in muscular subjects. It is also specially suitable for the treatment of supracondylar fractures, which are difficult to control by conservative means. In the treatment of compound fractures it is rivalled only by the closed plaster method and possibly by the automatic ambulatory method.

Effect on Knee Joint.

In the case of men between twenty and fifty-five years of age in whom traction has had to be strong, it may take many months before 90° of flexion at the knee is achieved. Manipulation of the knee-joint under anæsthesia may be helpful, but this should never be undertaken until all tendency to œdema has gone and the knee exercises are no longer producing improvement. The treatment has not been satisfactory unless 90° of flexion at the knee joint is obtained in nine months.

Use of Plaster Cast.

Application of a plaster cast is the method frequently used for compound fractures, because it provides excellent treatment for the wound. It is the best method to employ in these fractures if the patient's general condition is satisfactory and the necessary facilities for applying the plaster are available. The patient is put on an orthopædic table and skeletal traction is maintained by means of a pin through the crest of the tibia. After the wound has been excised a plaster cast is applied with the hip and knee in a flexed position.

Plaster fixation has been abandoned as a treatment for simple fractures of the femur, because control of the position of the fragments by this method is well-nigh impossible, especially if the patients lose weight. It is different in the case of compound fractures—here the most important thing, initially, is the treatment of the wound. Moreover, on account of the muscle destruction, the control of the fragments in compound fractures may be somewhat easier. In any case, little callus formation occurs in a compound fracture during the first four weeks, and, if the position of the fragments is unsatisfactory when the cast is due to be altered, the surgeon can change to the use of skeletal traction. Some of the surgeons during the Spanish War used the plaster technique without discrimination or skill, and, as a result, shortening, loss of alignment and stiffness of the knee were frequent complications. It is generally conceded, however, that the method is specially valuable in war-time, since the patients treated in this way can be evacuated easily.

Skin Traction.

It has been claimed by many that skin traction is unreliable even for simple fractures and that its use results in pressure sores and knee joint stiffness. Others have taken the more moderate view that fractures requiring only a small amount of traction can be treated efficiently in this way. Only a few have remained consistent advocates of the method, but they include Watson-Jones and other men of wide experience.

The complete technique has recently been described once more.[1] Spinal or general anæsthesia is induced so that full relaxation of the muscles may be obtained. The objective is to reduce the fracture, if possible, before the splint is applied, so that slow reduction by traction will not be necessary. As soon as the patient has been anæsthetized, an attendant applies traction by pulling on the foot.

Technique of Application of Extension.

Two strips of "Elastoplast" extension plaster about three to four inches wide are used as traction tapes. They extend from two inches above the fracture to one inch above the malleoli, and are then joined to strong tapes eighteen inches long. The inner strip of plaster is one-quarter to one-half an inch anterior to the outer, so that there is a slight force counteracting the tendency for the limb to rotate outward. Anteriorly and posteriorly there must be left a portion of skin at least an inch wide to which no strapping is attached. This gives a path by which lymph can return from the extremity. The traction strapping is lightly bandaged to the limb with a soft encircling bandage three inches wide; circular bands of strapping must never be used, for they are certain to cause œdema.

When the strapping has been adjusted, the Thomas splint is slipped on to the limb. It is essential that the counter-traction should be exerted on the ischial tuberosity and so the ring must be a good fit. If it is just a little too big, a wedge of cotton wool is placed beneath the part diametrically opposite the ischial tuberosity to pull the ring into the correct position.

With the Thomas splint in position the limb is supported at the fracture site and traction is kept up for a few minutes or more until full length has been obtained. The extension straps are then knotted around the depression at the end of the splint.

Accessory splints are next added to complete the fixation, the most important being a back splint which extends from just below the fold of the buttock to the lower third of the leg. It is held in position by slings which pass behind it and are joined to the side pieces of the splint. In order to maintain the anterior bow of the femur the back splint is slung so that two-thirds of the thigh lies in front of the lateral bars of the splint. Two woollen pads are placed between the back splint and the limb: one is used particularly in supracondylar fractures, to keep the upper end of the lower fragment from being displaced backwards, and another, about two inches thick, is placed behind the knee so as to maintain some 10° of flexion. If the knee is immobilized in full extension, there is always great difficulty in restoring knee movement.

Two accessory lateral splints may be placed on the thigh in the region of the fracture so as to give additional support. There is no need for any appliance to prevent foot-drop, provided foot exercises are undertaken regularly.

A skiagram is taken about every two weeks to check the position of the fragments. Angulation can be corrected by the use of pads of wool. Maintenance of length is estimated by measurement of the limb rather than by the use of radiographs.

Skin Traction by Russell's Method.

In Russell's method[4] adhesive straps are applied to the sides of the leg, and a pillow is placed under the knee joint so as to flex it 20° to 25°. Traction is exerted in two directions by means of a continuous cord. One end of the cord is attached to a padded sling which passes under the knee joint; the cord then extends upwards to an overhead pulley which lies vertically above the lower limit of the anterior tuberosity of the tibia. In this way a force is applied at an angle of about 45° to the projected line of the femur. The cord then passes from the overhead pulley to a pulley on a horizontal bar at the foot of the bed; then to a pulley attached to tapes which apply skin traction to the leg; then to a second pulley on the horizontal bar, and finally down to a sack of weights. The horizontal bar is on the same level as the tibia, and the pulleys on it are so close together that the cords connecting them to the pulley on the extension tapes are parallel. Therefore, a double force is exerted in the line of the tibia. The resultant pull of this force and the upward force is in the line of the femur, and its magnitude is somewhat more than twice the value of the weights in the bag. These weights, therefore, need to be only five to ten pounds.

The overhead beam is so arranged that the injured leg is abducted about 15°. To provide counter-traction, the foot of the bed is raised on blocks about eight inches high. If the fragments are not in satisfactory alignment within forty-eight hours, manipulation should be carried out under anæsthesia without interruption of the traction. Radiographs should be taken every day for the first few days.

The apparatus requires constant supervision by a staff that understands the mechanics of the method. The correct amount of slight flexion must be maintained at the knee and hip; the overhead pulley must be kept in proper relationship to the tibia; and the patient must not be allowed to slide down the bed.

Russell traction is the best treatment for fractures of the intertrochanteric region, and is usually effective in any fracture of the upper third of the shaft. It is satisfactory in oblique and comminuted, but not in transverse, fractures of the middle third. It is least likely to succeed in fractures of the lower third and supracondylar region.

Automatic Ambulatory Method.

In the automatic ambulatory method, as used by Roger Anderson, two pins are inserted, at a fixed angle to each other, into the proximal fragment in the region of the trochanter, and two pins are passed perpendicularly into the distal fragment near the knee. The upper pins are inserted at an angle in order to secure a better grip; their points must penetrate deeply enough to pierce and engage the inner cortex, and their outer ends are held in a fixing clamp. The lower pins are inserted about two inches apart and in slightly different planes. All the pins are put in under local anæsthesia and their position is checked by means of skiagrams.

The patient is then put on the fluoroscopy table and the fractured leg is placed in a special traction apparatus which is attached to the fixing clamp holding the upper pins and to one or other of the lower pins. This apparatus makes it possible to carry out every manipulation required, including rotation, by mechanical means. Excessive traction is used at first to hasten reduction and remove any interposed muscle. The reduction is so efficient that care has to be taken to prevent over-traction.

A plaster cast may then be applied, extending from the groin and buttock to the knee, and incorporating the fixation apparatus. The hip joint and knee joint, however, are left free. The plaster gives support and protection to the soft tissues, but is not essential, and in some variations of this method the pins are merely locked together by an external bar, after the fracture has been reduced.

The patient is usually able to leave hospital within a week. Weight-bearing can be resumed gradually as confidence is gained. The period of immobilization varies from six to twelve weeks.

The method of external mechanical fixation probably has its greatest field of application in fractures of the femur, especially those that cannot be treated successfully by other means. The method does not decrease stiffness of the knee as much as was hoped, since movement at the knee joint is very restricted when the apparatus is in position. It does, however, give a better reduction, surer fixation, and the advantages of an ambulatory treatment. The fact that strict radiographic control and clinical supervision are not so important in this method, gives it a special war-time value.

Against these advantages have to be weighed the following: the possibility of infection entering through the pin tracks; the liability to over-traction; and the relative difficulty of learning to use the apparatus.

Open Reduction and Plating.

Open reduction and plating is an operation which should be done only by those familiar with the strict standards of asepsis required. The fracture site is exposed and accurate reduction accomplished. Fixation may sometimes be achieved by means of screws or bands alone, but plating is necessary to overcome angulation. The screws should be long enough to engage the opposite cortex. All the agents for internal fixation are made of stainless steel or vitallium. The internal fixation apparatus alone will not usually hold the fragments in position, so that some form of simple external fixation is required as well.

Open reduction is usually considered the last resort, being employed only after other methods have failed to secure satisfactory reduction. Some American surgeons, however, regard it as the method of choice, and use it almost as a routine. It gives a means of securing accurate reduction, and of dealing with any muscle that has become interposed between the two fragments; but it has serious disadvantages: (*a*) There is the possibility of introducing infection; this is so serious a complication that many surgeons do not feel justified in risking it. (*b*) The stripping of muscles and periosteum interferes with the blood supply of the bone. (*c*) In the healing of the soft tissues muscle adhesions are produced, and knee joint movements may be permanently limited by them.

Summary of Various Methods of Reducing and Immobilizing the Femur.

At the present time the open reduction and the automatic ambulatory methods have limited application, though the latter appears to be increasing in popularity. The experience of the other methods at Pearl Harbour was that shortening and poor alignment occurred in all cases unless traction was used, and skeletal traction was more efficient than skin traction. As mentioned before, however, plaster fixation has some advantages in the treatment of compound fractures.

Variations in treatment according to the different sites of fracture may be described in the following way, though many surgeons have individual preferences.

1. Subtrochanteric fractures may be treated by Russell traction or by "well-leg" traction, if reduction is unstable, and by a plaster spica or abduction frame if reduction is stable.
2. Fractures of the upper third of the shaft are best treated by Russell traction.
3. Fractures of the middle and lower thirds are best treated by skeletal traction or skin traction.
4. Supracondylar fractures may be treated by skeletal traction.

Treatment at Two Overseas Australian General Hospitals of Patients with Gunshot Fracture of the Femur.

Articles have been published giving the experience gained at two Australian general hospitals in the treatment of fractured femur during this war.[2][3] The authors do not propose new methods of treatment, but they show how existing knowledge can be applied to the special problems of treating wounded soldiers for fractured femur. The chief aspects discussed are: (*a*) the nature of gunshot injuries; (*b*) foreign bodies in wounds; (*c*) segregation of patients with fractures; (*d*) reduction and immobilization; (*e*) maintenance of joint function; (*f*) the problem of comminuted fractures; (*g*) gravitational abscess; (*h*) general sepsis; (*i*) amputation; and (*j*) end-results.

The Nature of Gunshot Injuries.

Many instances have occurred in which both the wound of entrance and the wound of exit were small, but the intervening tissue was grossly damaged. This phenomenon was, of course, observed in the Great War and has been explained by the experimental work of Zuckerman and others. High velocity fragments, even though small in size, have a big momentum, and can cause extensive disruption of tissues. Skin is so elastic that it can stretch during the passage of the missile and remain relatively intact; but bone and muscle suffer more heavily. It is not the irregular shape of missiles that causes maceration of muscles, and neither large size of fragment nor "wobble" is essential to the production of severe wounds, although, of course, they tend to increase the damage.

Foreign Bodies in Wounds.

Large foreign bodies almost always cause persistent infection. In one series of patients,[3] six had large foreign bodies which had been left in the damaged tissue for more than twelve days. Of these patients, only one made an uncomplicated recovery; one died, another required an amputation, and the remaining three were still developing intermuscular abscesses after seventeen weeks of treatment. In the other series of patients there were three men with large foreign bodies, and all had persistent sinuses. In two instances the foreign bodies were eventually removed and the sinuses then healed permanently within a few days.

Segregation of Patients with Fractures.

In one hospital most of the patients with fractures were gathered together into one ward. This scheme worked well in that the treatment could be standardized, and the patients were happier when separated from those who had only a short stay in hospital.

Reduction and Immobilization.

The fracture was reduced by manipulation under general anæsthesia.

Immobilization in plaster did not usually prove satisfactory in the early treatment of fractured femur. For the proper application of a hip spica it is necessary to have a traction table, a portable X-ray machine and surgeons who are experienced in plaster work. These were not always available, and it was therefore more common to use skeletal traction in association with a Thomas splint.

In the absence of Pearson attachments, the splints were bent at the level of the knee, or, in the case of supracondylar fractures, at the level of the fracture. In subtrochanteric fractures the uninjured limb had to be slung as well in order to maintain abduction at the hip on the fractured side.

Maintenance of Joint Function.

The foot of the immobilized limb was exercised daily, but the slight movement possible at the knee joint was not considered worth while in view of its probable effect in delaying union. The patient was encouraged to move the uninjured limb as much as possible.

The Problem of Comminuted Fractures.

Comminuted fractures were relatively common, numbering five out of 32 in one series. The important point about them is that maintenance of reduction is difficult, and shortening may occur after many weeks of efficient immobilization, if the traction is not maintained.

Gravitational Abscess.

In compound fractures with extensive sepsis, pus tends to gravitate along muscle and fascial planes. The usual treatment for fractured femur requires the knee to be higher than the hip, so that infection tends to gravitate towards the gluteal region. A careful watch should be kept for abscesses and they should be drained by adequate incisions as soon as they are detected. It is also suggested that a plaster cast may be useful in some cases, since it enables the surgeon to immobilize the limb in a horizontal position.

General Sepsis.

The most frequent complication was sepsis. The interesting observation was made that some patients who lay for long periods before being attended to by stretcher bearers did not develop infection. This apparently contradicts the rule that the lag period between contamination and infection is only six hours; but a possible explanation is that, unless the patient himself carries virulent organisms, he is not in great danger of developing pyogenic infection until he comes in contact with other people.

Sepsis was much more severe in many cases than it is in corresponding fractures of civilian life. Pyrexia and a pulse rate of 130 to 140 per minute sometimes persisted for weeks. Loss of appetite and insomnia led to marked wasting, and pressure sores readily developed in the atrophic skin. Anæmia was common and had to be treated by blood transfusion.

Amputation.

A mid-thigh amputation causes a serious disability to a working-man, but it is a life-saving measure for many patients with chronic infection following compound fractures of the femur. It has been pointed out that these patients are so thin that the operation is quick and simple and the degree of shock produced not very great. In making a decision regarding the need for amputation in these patients, the following considerations are important: (*a*) the appetite; (*b*) the pulse rate; (*c*) the rate of fall of the hæmoglobin content; and (*d*) the rate at which emaciation is developing.

End-Results.

Seven patients out of 53 died. The patients who survived were usually classified as "C2" or "D". The time taken for definite evidence of union of the fragments varied from eight to twelve weeks in eleven patients for whom the data are available.

References.

(1) W. S. Diggle: "The Thomas Splint in the Treatment of Fractured Femur", *The Lancet*, September 26, 1942, page 355.
(2) B. T. Keon-Cohen: "Fractures of the Femur in War-Time: A Review of Thirty-Two Cases", *The Australian and New Zealand Journal of Surgery*, Volume XII, January, 1943, page 163.
(3) L. Lindon: "Compound Fracture of the Femur due to Gunshot Wounds", *The Australian and New Zealand Journal of Surgery*, Volume XI, April, 1942, page 235.
(4) R. H. Russell: "Fracture of the Femur: A Clinical Study", *The British Journal of Surgery*, Volume XI, 1924, page 491.
(5) D. P. Walker: "Fractures of the Shaft of the Femur", *Surgical Clinics of North America*, Volume XX, December, 1940, page 1743.